Self-Healing Field-Emission Neutralizers for Electric Propulsion, Phase I

Completed Technology Project (2011 - 2011)

Project Introduction

Electric propulsion (EP) thrusters have the potential to enhance or enable Discovery-class missions. However, a significant challenge in scaling micro (< 100 W) EP devices up as well as scaling macro (> 1 kW) EP devices down is the lack of a compatible neutralizer technology in the meso scale (< 1 kW). Traditionally, the technology used for spacecraft neutralization has been the hollow cathode, though hollow cathodes require an unsatisfactory fraction of a propulsion system's propellant and power in the meso-scale regime. In fact, they require such a large amount of propellant and power that system efficiency is reduced by 50-100%. In addition, using a hollow cathode causes undesirable specific impulse reduction. The most promising technology for meso-scale neutralizers is field emission (FE), which requires the use of nano-scale sharp emitters and high electric fields to establish a beam of electrons. The drawback of FE devices is that the nano-scale emitters become damaged when operated in elevated pressure environments (10-5 Torr), causing catastrophic failure. The research proposed here is to develop field-emission cathodes for use in meso-scale EP that eliminate tip degradation not through attempts to minimize tip wear, but instead by incorporating self-assembling nanostructures that can repeatedly re-generate damaged emitter tips in space and fully restore the functionality of a damaged or degraded cathode. The procedure is the equivalent of having a MEMS fabrication and repair lab on-board the spacecraft. The re-generable emitters proposed here have been successfully demonstrated in the laboratory in work by Makela, et. al. dating back to 2007. The re-generable neutralizers could enable highly efficient, high-Isp, low-mass propulsion systems operating between a few Watts and 1 kW by either scaling existing micro technologies up or scaling existing macro technologies down.

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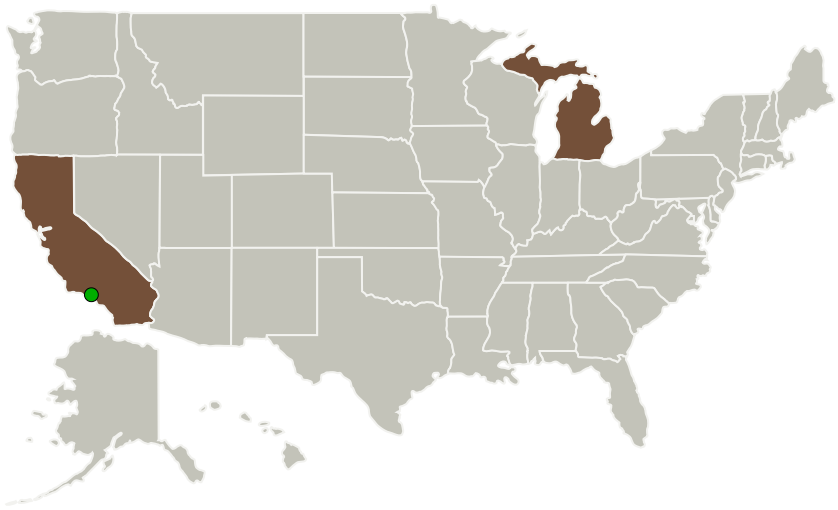
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Aerophysics, Inc.	Lead Organization	Industry	Allouez, Michigan
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Michigan

Project Transitions

February 2011: Project Start

September 2011: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/138490)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Aerophysics, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Jason M Makela

Co-Investigator:

Jason Makela

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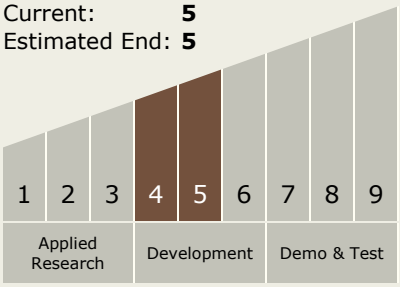
Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.2 Electric Space Propulsion
    - TX01.2.1 Integrated Systems and Ancillary Technologies

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System